ably in brightness. Unfavourable weather in the morning hours prevented me from observing it any further.

I calculated the following parabolic elements from the observations, Berl., Dec. 5, Dec. 26, Leyton, Jan. 11, taking into the account the corrections of Aberration and Parallax:—

T	1863, Feb. 3·48790 M.G.T.	
π	191 22 12·4	Mean Eq. 1863·0
Ω	116 55 19·7	
i	85 21 34·2	
log q	9·9002614	
	Direct.	

These elements give for the mean place the error

C − O $\quad \Delta\alpha = -0''\cdot7 \quad \Delta\delta = +7''\cdot1$

On a mode of Figuring Glass Specula for the Newtonian Telescope. By the Rev. Henry Cooper Key.

As the subject of silvered glass specula is now beginning to attract some attention, I have taken the liberty of laying before the Society a brief account of the successful manufacture of these specula, including a method which I have suggested for producing with great ease and certainty the true parabolic figure necessary for first-rate performance.

The machine used for the purpose is the same in principle as that of the Earl of Rosse, and very similar in detail, but with some slight modification in the speed of the various parts. The number of strokes to one revolution of the speculum-plate is 104. The pin of the eccentric giving the side motion is carried from side to side with an unequal velocity by means of an oval wheel, whereby the centre is passed over rapidly and the action is prolonged at the two extremes. The number of revolutions of the side-motion eccentric to one revolution of the speculum-wheel is $5\frac{1}{2}$. The amounts of stroke and side-motion found to produce the best results are stroke = $\frac{1}{3}$ diameter of the speculum and side-motion $\frac{1}{4}$ the same; but precision on this point does not appear to be very material.

The glass disc is ground upon a cast-iron tool, of the same diameter as itself, carefully turned to the guage, and scored at right-angles into facets $\frac{5}{8}$-in. square; these grooves are filled up with wax or pitch until the rough grinding is complete, or nearly so. It is not absolutely necessary to work a concave iron tool upon the convex, the simplest plan being to figure

the convex tool by means of the speculum itself; or, if more than one is to be worked, by grinding them alternately upon it. The convex tool should be turned to a curve giving about 6 inches less focal length than that ultimately desired, to allow for the lengthening that will take place in the course of the grinding.

The fine grinding is effected by means of emery of six different degrees of fineness, commencing with flour-emery as No. 1; these are, of course, obtained by washing and pouring off the finer particles while in suspension. The sixth, or finest quality, takes between two and three days to settle. The last application is slate-mud, carefully washed, and mixed with a very little rouge, also washed. Rouge always contains some amount of grit, and should never be used unwashed.

As the character of the spherical figure, upon which the quality of the future mirror entirely depends, is given in fine grinding upon the iron tool, it is advisable to prolong the process of fine grinding considerably, and to bring the surface, in fact, to such a fine degree of semi-polish, that, when placed with wet rouge on the pitch-tool, it shall come up to a perfect polish in from three to four hours. The shorter the sojourn of the speculum on the pitch-tool the better. I need scarcely add that no rings of unequal polish ought to appear during any part of the fine grinding.

The pitch polishing tool may be made either of two pieces of seasoned wood glued together across the grain, or of slate. It should be turned to the guage, and, as it should be of the same size as the speculum when coated with pitch, it must be about $1\frac{1}{2}$ inches larger in diameter, to allow of the margin being perfect. The pitch is hardened with resin, until the thumb-nail can make little or no impression upon it when cold: the harder it is the better, provided it be not too brittle. It is to be scored, while still warm, into squares or facets, which, after some hours' work upon the machine, shall not exceed $\frac{1}{2}$-in. square on the surface, and shall stand at least $\frac{3}{8}$-in. high, the base of each facet being not less than $\frac{7}{8}$-in. square. It is of great importance that they stand well detached from one another, that they may give equally to pressure in all directions. In polishing, as well as in grinding, the speculum is placed uppermost.

The speculum, when polished and placed in the tube, and directed to a fine watch-dial at about 100 yards' distance, will now show that the extreme marginal rays come to a focus about $\frac{1}{4}$-inch inside the central rays—proving thereby a spherical figure.

To give the parabolic figure, which shall unite all the rays in one precise focus, proceed with a sharp chisel to cut the facets of the pitch-tool smaller, leaving the four centre ones untouched, and gradually diminishing the surface of the others over the whole face of the tool, until those at the margin are

reduced to $\frac{1}{4}$-inch square, or even a little less. The proper amount of graduation is obtained by experience, and upon the judicious execution of this the quality of the speculum will depend. The speculum is now placed upon the graduated tool, and the action of the machine continued with the same amount of stroke and side-motion as before, until, supposing its surface divided by diaphragms into four nearly equal zones—outer, second, third, and central—it gives equally perfect definition on the dial, and bears an equally high power, with each zone, at precisely the same focal point. This is attained usually in a few hours, without any difficulty. I ought perhaps to add, by way of caution, that the stroke and side motion must not be altered in amount in the slightest degree from the commencement of the fine grinding to the completion of the figure, and more especially the side motion.

This is the normal mode of procedure; but, by way of precaution, it is advisable to graduate the pitch-tool very slightly before commencing the polishing; and when that is quite perfect (and not the slightest granulation must be left visible), the tool is to be fully graduated, as before stated.

My first experiment with the graduated tool, when the idea occurred to me, was made on a half-polished mirror, and in two and a half hours the definition became such as to surprise me. With a half-polished mirror, unsilvered, 12-inches aperture and power of 1000, the dial was exquisitely defined; with 350 the effect was that of viewing the dial itself close to the eye without the intervention of a telescope; and a fly resting on the well-focussed dial remained itself out of focus, with the exception of its feet, forcibly reminding me of the definite focal plane of a good achromatic microscope: the mirror, in fact, came up to focus and went out—in an instant—with the sharp precision of a microscope.

No more severe test is required, or indeed can be found, to insure fine performance on celestial objects, than the dial, and the mode of procedure above mentioned.

The speculum is to be silvered by Liebig's process; and the coat should be rather thin, as, if thick, it is liable to lose its fine figure by rubbing up. The silver will never tarnish if kept dry. A small bag should be kept in the same box with it, containing sawdust which has been saturated with chloride of calcium, and dried.

Circumstances over which I had no control have prevented my own further progress, and, indeed, I shall be delayed some weeks longer before I am able to resume the work; but having, last autumn, communicated my method to Dr. Frankland, of the Royal Institution, and to Mr. With, Master of the Bluecoat School at Hereford, I am able to state what they have accomplished.

Dr. Frankland immediately and readily figured a speculum of 7 inches' aperture, whose spherical figure was not good (it

having been polished by hand on paper), so that it would split 36 *Andromedæ* with 210, clearly and sharply. He, however, expects superior results from a machine-made speculum, and speaks in the highest terms of my suggestion of the graduated pitch-tool.

Mr. With, of Hereford, in his small intervals of leisure during the last three months, has completed three or four glass specula of the highest class, $6\frac{1}{4}$-inches aperture and 6-feet focus, and $5\frac{1}{2}$-inches aperture and $4\frac{1}{2}$-feet focus. With the larger telescope he is able to elongate the disk of the small companion of γ *Andromedæ* readily. Its definition of a large fixed star is remarkably fine, giving a perfectly round clean disk, surrounded at a little distance by one faint concentric ring, and without any other appendage or false light whatever.* This was his first attempt. One of his $5\frac{1}{2}$-inches specula is, however, slightly superior to this, and is presumed to be perfect: not the least trace of error of figure can be detected over the entire surface after the strictest scrutiny.

The belief is, after sundry trials and comparisons with achromatics, that the silvered-specula Newtonian is very little, if at all, inferior in efficiency to the finest achromatic of the same aperture. Should this be confirmed by future experience, as I fully anticipate it will be, the former will prove to be formidable rivals to the latter, as the cost of making is not likely to amount to one-eighth or even one-tenth of the achromatic object-glass.

I have omitted to mention that excellent small glass flats for silvering may be obtained from the common French plate-glass—the best from the middle of the plate.

Should any member of the Society desire further information beyond what I have been able to convey in these brief notes, I shall be happy to give it at any time.

Stretton Rectory, Hereford,
March 9th, 1863.

Companion of Sirius.

(*Extract of a Letter from the Rev. W. Dawes.*)

"Goldschmidt's star *d* near *Sirius* is easy enough, but I have not been able to perceive any of the others. In fact, such

* The fifth star in the trapezium in *Orion* is visible as a steady object, and the sixth in moments of fine vision. The distant comes of λ *Orionis*, not mentioned by Smyth, is an easier object in this telescope than the fifth star in the trapezium. In the triple star ζ *Orionis* the separation between the close pair is equal to one diameter of the large star with a power of 220.